Claims

1. Apparatus for moving a stream of molten metal in a bath of the molten metal comprising:

a pumping member adapted to be disposed in a bath of a heated molten metal, and to move a stream of the molten metal as the pumping member is driven in a path of motion;

a housing at least partially enclosing the pumping member;

a shielding means carried on the pump housing, the shielding means having an internal shaft-receiving opening;

a power device adapted to be supported above the bath of molten metal, and to be actuated in a powered motion;

means for connecting the power device to the pumping member to move the pumping member in said path of motion, comprising;

a pumping shaft having an upper end connected to the power device so as to be moved when the power device is actuated, and a lower driving end connected to the pumping member to drive the pumping member in said path of motion when the power device is actuated;

the driving end of the shaft having a first coefficient thermal expansion and the socket having a different coefficient of thermal expansion; and

the shaft means being disposed in the shielded means out of contact with the molten metal, and forming a chamber between the shaft and the

shielding means sufficient to permit thermal expansion of the shaft without imposing a radial thermal stress on the shielding means.

2. Apparatus as defined in claim 1, in which the pumping member is rotated in said path of motion.

3. Apparatus as defined in claim 1, in which the power device is a motor connected to the pumping shaft for rotating same.

4. Apparatus as defined in claim 1, in which the pumping member is an impeller pumping element.

5. Apparatus as defined in claim 1, in which the pumping shaft is made of a steel alloy with sufficient torque characteristics to rotate the pumping member in the molten metal.

6. Apparatus as defined in claim 5, in which the pumping shaft is made of stainless steel.

7. Apparatus as defined in claim 1, in which the shielding means comprises an elongated tubular shield telescopically enclosing the pumping shaft, the tubular shield having a lower end attached to the pump housing, and an upper end, the tubular

shield having a length such that the upper end is disposed above the metal surface of the bath of molten metal.

8. Apparatus as defined in claim 7, in which the pumping shaft is rotatably connected to the pumping member, and the tubular shield encloses the pumping shaft but does not rotate therewith.

9. Apparatus as defined in claim 7, in which the pumping shaft is formed of a steel alloy that has sufficient torque characteristics as to be capable of rotating the pumping member in the molten metal, and

the tubular shield is formed of a ceramic material with sufficient heat-resisting characteristics as to withstand the heat of the molten metal as the pumping member is being rotated.

10. Apparatus as defined in claim 7, in which the tubular shield includes:

an outer tubular shield having a lower end attached to the pump housing;

an inner tubular shield telescopically disposed in said outer tubular shield and being attached thereto;

the inner tubular shield having a bore with a diameter greater than the diameter of the pumping shaft, and enclosing the pumping shaft to form a chamber therearound;

the lower end of the inner shield forming a shoulder; and

structure disposed on the lower end of the shaft engaging the shoulder to locate the lower end of the shaft with respect to the inner shield.

11. Apparatus as defined in claim 7, in which the tubular shield means includes:

an inner tubular shield telescopically disposed in said outer tubular shield and being attached thereto;

the inner tubular shield having a bore with a diameter greater than the diameter of the shaft, and enclosing the shaft so as to form a chamber therearound;

the lower end of the inner tubular shield being spaced from the lower end of the outer tubular member to form a driving chamber;

a driving structure supported on the lower end of the shaft enclosed within the outer shield; and

cement disposed in the outer shield having a socket accommodating the configuration of said driving structure, the driving structure being disposed in said socket but having a clearance therebetween to accommodate the relative thermal expansion characteristics of said driving structure and the socket, but permitting the driving structure to be rotated to engage the socket wall in the cement to rotate the pumping member.

12. Apparatus as defined in claim 11, in which the driving structure has a tongue-shaped configuration.

13. Apparatus as defined in claim 11, in which the driving structure is threadably attached to the lower end of the shaft.

14. Apparatus as defined in claim 11, in which the driving structure is integrally attached to the lower end of the shaft.

15. Apparatus as defined in claim 11, in which the clearance between the driving structure and the socket is formed by the steps of:

forming the outer tubular shield with a lower blind end;

disposing a cement in the blind end of the outer tubular shield to form a socket having the configuration similar to but larger than that of the driving structure;

disposing a wax that turns to a gas when exposed to the heat in the bath of molten metal, in said socket;

disposing the driving structure in the wax; and

telescopically inserting the inner tubular shield in the outer tubular shield to engage the driving structure, and cementing the inner tubular shield to the outer tubular shield to form a unitary tubular shield around the pumping shaft.

16. A combination, comprising:

pot means for containing a bath of molten metal;

a pumping member adapted to be disposed in a bath of a heated molten metal, and to move a stream of molten metal as the pumping member is driven in a path of motion;

a housing at least partially enclosing the pumping member;

a shielding means carried on the pump housing, the shielding means having an internal shaft-receiving opening;

a power device adapted to be supported above the bath of molten metal, and to be actuated in a powered motion;

means for connecting the power device to the pumping member to move the pumping member in said path of motion, comprising;

a pumping shaft having an upper end connected to the power device so as to be moved when the power device is actuated, and a lower driving end connected to the pumping member to drive the pumping member in said path of motion when the power device is actuated;

the driving end of the shaft having a first coefficient of thermal expansion and the socket having a different coefficient of thermal expansion; and

the shaft means disposed in the shielding means out of contact with the molten metal, and forming a chamber between the shaft and the shielding means sufficient to permit thermal expansion of the shaft without imposing a radial thermal stress on the shielding means.

17. A combination comprising:

pot means for containing a bath of molten metal;

a pumping member adapted to be disposed in a bath of a heated molten metal, and to move a stream of the molten metal as the pumping member is driven in a path of motion;

means on the pumping member forming a socket;

a power device adapted to be supported above the bath of molten metal, and to be actuated in a power of motion;

means for connecting the power device to a pumping member to move the pumping member in said path of motion, comprising;

the tubular shield enclosing the shaft.

18. Apparatus for moving a stream of molten metal in a bath of the molten metal comprising:

a pumping member adapted to be disposed in a bath of a heated molten metal, and to move a stream of the molten metal as the pumping member is driven in a path of motion;

a power device adapted to be supported above the bath of molten metal, and to be actuated in a powered motion;

means for connecting the power device to the pumping member to move the pumping member in said path of motion, comprising;

a shaft adapted to be connected to the power device to be rotated thereby;

a shield means of a heat resistant material telescopically receiving the shaft and having a length longer than the shield means so that the lower end of the shield means extends beyond the lower end of the shaft

means connecting the shaft to the shield means to rotate the shaft and shield together; and

means connecting the shield means to the pumping member to rotate the shield means and the pumping member together.

19. Apparatus as defined in claim 18, in which the pumping member is rotated in said path of motion.

20. Apparatus as defined in claim 18, in which the power device is a motor connected to the shaft for rotating same.

21. Apparatus as defined in claim 18, in which the pumping member is an impeller pumping element.

22. Apparatus as defined in claim 18, in which the shaft is made of a steel alloy with sufficient torque characteristics to rotate the pumping member in the molten metal.

23. Apparatus as defined in claim 18, in which the shaft is made of stainless steel.

24. Apparatus as defined in claim 18, in which the shaft is formed of a steel alloy that has sufficient torque characteristics as to be capable of rotating the member in the molten metal, and

the shield means is formed of a ceramic material with sufficient heat resisting characteristics as to withstand the heat of the molten metal as the pumping member is being rotated.

25. Apparatus as defined in claim 18, including a pump housing at least partially enclosing the pumping member, and in which the tubular shield means includes an outer tubular shield having a lower end attached to the pump housing; and

an inner shield telescopically disposed in said outer tubular element and being cemented thereto the shaft being connected to the inner shield.

26. Apparatus as defined in claim 18, including a pump housing at least partially enclosing the pumping member, and in which the shield means includes:

an outer tubular shield having a lower end attached to the pump housing,

an inner tubular shield telescopically disposed in said outer tubular shield and being cemented thereto;

the inner tubular shield having a bore with a diameter greater than the diameter of the pumping shaft, and enclosing the pumping shaft so as to form a chamber therearound;

the lower end of the inner tubular member being spaced from the lower end of the outer tubular member to form a shoulder;

a structure disposed adjacent the lower end of the drive shaft having a diameter greater than the diameter of the bore of the inner tubular shield but less than the diameter of the outer shield to form a shoulder, and the structure engages the shoulder to locate the lower end of the shaft with respect to the tubular shield; and

cement disposed in the lower end of the outer shield with a socket accommodating the configuration of the lower end of the shaft but having a clearance therebetween to accommodate the relative thermal expansion characteristics of said driving end to be rotated into the socket to rotate the pumping member.

27. Apparatus as defined in claim 26, in which the lower end of the shaft has a tongue-shaped configuration.

28. Apparatus as defined in claim 26, in which a clearance between the lower end of the shaft and the socket is formed by the steps of:

forming the outer shield with a lower blind end;

disposing a cement in the blind end of the outer tubular member to form a socket having the configuration similar to but larger than that of a driving end;

disposing wax that turns to gas when exposed to a heat in the bath of molten metal in said socket;

disposing the lower driving end of the shaft in the wax;

inserting the inner tubular member into the outer tubular member so as to engage the driving end of the pumping shaft, and

cementing the inner tubular member to the outer tubular member to form a unitary tubular shield around the shaft.

29. Apparatus as defined in claim 18, in which the shield means comprises an inner tubular graphite shield telescopically receiving the shaft;

an outer tubular graphite shield telescopically receiving the shaft and the inner tubular graphite shield; and

a tubular shield telescopically receiving the shaft, the inner graphite shield and the outer graphite shield.

30. Apparatus for moving a stream of molten metal in a bath of molten metal having a metal level, comprising:

power means adapted to be supported above the metal level of the bath;

a shaft having an upper end connected to the power means for rotation thereby, and a lower end;

a pump housing adapted to be disposed in the bath of molten metal;

the pump housing having a pumping chamber;

a pumping member disposed in the pumping chamber and connected to the lower end of the pumping shaft for rotation therewith to produce a stream of the molten metal;

the housing having a bottom inlet opening for receiving the molten metal into the pumping chamber;

strainer means mounted on said inlet opening; and

the housing having feet for supporting the housing above the floor of a pot containing a molten metal such that the bottom opening faces toward the floor of the pot when receiving molten metal therein through the inlet opening.

31. Apparatus for moving a stream of a molten metal in a bath of molten metal, comprising:

power means adapted to be supported above the metal level of the bath;

a shaft having an upper end connected to the power means for rotation thereby, the shaft having a lower end;

a pump housing;

the pump housing having a pumping chamber, an inlet opening for receiving molten metal into the pumping chamber;

a strainer disposed in said inlet opening and having strainer openings with a diameter chosen to prevent the entry of debris of a maximum diameter into the pumping chamber; and

the pumping member connected to the pumping shaft for rotation therewith, the pumping member having pumping vanes for moving the molten metal, the vane having vane openings therebetween greater than the strainer openings, whereby debris entering the inlet opening is smaller than the vane openings between the vanes.

32. Apparatus for moving a stream of molten metal in a bath of molten metal comprising:

a pumping member adapted to be disposed in a bath of heated molten metal and to move a stream of molten metal as the pumping member is driven in a path of pumping motion;

a power device adapted to be supported above the bath of molten metal and to be actuated in a powered motion;

means for connecting the power device to the pumping member to move a pumping member in said path of pumping motion;

a pump housing having a pumping chamber and an inlet opening, the pumping member being disposed in the pump housing, the inlet opening being adapted for receiving molten metal into said pumping chamber;

the pumping member having a strainer plate having apertures for receiving molten metal into the pumping chamber as the pumping member is being rotated about an axis of rotation; and

a slinger rib mounted on the strainer plate adjacent the apertures and upstream thereof so as to strike debris carried into the stream toward the apertures, in a direction away from said inlet opening as the pumping member is being rotated.

33. Apparatus as defined in claim 32, in which the strainer plate has a convex configuration including a planar bottom bounded by a frusto-conical side wall, and the planar bottom has said apertures, and including other apertures in the frusto-conical side wall.

34. Apparatus as defined in claim 33, in which the slinger rib is mounted between the apertures in the slinger bottom, and including another slinger rib mounted on the frusto-conical wall between the apertures therein.

35. Apparatus for moving a stream of molten metal in a bath of the molten metal beneath overhead structure, comprising:

a pump housing adapted to be disposed in a bath of molten metal below the metal level;

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leg means disposed between the pump housing and the overhead support structure, comprising:

a steel alloy leg having an upper end and a lower end, the leg having a sufficient compressive strength to prevent the pump housing from rising in the molten metal;

means for connecting the leg to the overhead support structure;

a tubular shield means enclosing at least a portion of the leg, and being formed of a material resistant to the heat of the molten metal; and

the tubular shield means having a lower end attached to the pump housing, and an internal bore having a diameter greater than the diameter of the leg to accommodate the leg's thermal expansion caused by the heat in the molten metal bath.

36. Apparatus as defined in claim 35, in which the pump housing has an opening, the tubular shield has a lower end disposed in said opening, and structure on the lower end of the shield for preventing withdrawal of the shield through said opening.

37. Apparatus as defined in claim 36, in which said structure comprises a nut threadably mounted on the lower end of the shield.

38. Apparatus as defined in claim 36, in which the structure is an integral enlargement carried on the lower end of the shield, said enlargement being larger than the opening in the housing.

39. Apparatus as defined in claim 36, in which the tubular shield is made of a heat-resistant ceramic.

40. Apparatus as defined in claim 36, in which the shield means comprises an outer ceramic tubular shield, and an inner ceramic tubular shield telescopically received in the outer shield and cemented thereto, the inner shield being shorter than the leg whereby both ends of the leg extend beyond the ends of the inner shield, and upper fastener means are connected to the upper end of the leg and engageable with the upper end of the inner shield, and lower fastener means threadably fastened to the lower end of the leg and engaged with the lower end of the inner shield for cooperating with the fastener means in locating the leg in the bore of the inner shield.

41. Apparatus as defined in claim 40, in which the bore of the inner shield, and the leg form a gas chamber, and including means for introducing an inert gas into the gas chamber to form an oxygen-free environment around the leg.

42. Apparatus for moving a stream of a molten metal in a bath of the molten metal, comprising:

overhead structure disposed above the molten metal level;

a pump having a housing, the housing having an upwardly facing socket;

a vertical leg disposed between the overhead structure and the pump housing;

the socket having a cylindrical side wall and an annular groove therein;

the leg having an annular groove; and

a split retaining ring carried in the groove of the leg and in the annular groove in the socket to prevent removal of the leg from the socket.

43. Apparatus as defined in claim 42, in which the split ring is diametrically resilient so as to be squeezed toward the base of the groove in the leg to permit passage of the ring into the socket opening.

44. Apparatus as defined in claim 42, in which a socket has a chamfered opening to assist in squeezing the ring into the groove in the leg as the leg is being passed into the socket.

45. Apparatus for moving a stream of a molten metal in a bath of the molten metal, comprising:

overhead structure disposed above the molten metal level;

a pump having a housing, the housing having an upwardly facing socket;

a vertical leg disposed between the overhead structure and the pump housing;

the socket having a cylindrical side wall and an annular groove therein; and

including cement received in the groove in the socket for fastening the leg to the housing.